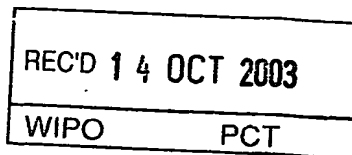


PRVPATENT- OCH REGISTRERINGSVERKET
Patentavdelningen**Intyg
Certificate**

Härmed intygas att bifogade kopior överensstämmer med de handlingar som ursprungligen ingivits till Patent- och registreringsverket i nedannämnda ansökan.

This is to certify that the annexed is a true copy of the documents as originally filed with the Patent- and Registration Office in connection with the following patent application.



(71) Sökande DeLaval Holding AB, Tumba SE
Applicant (s)

(21) Patentansökningsnummer 0202879-3
Patent application number

(86) Ingivningsdatum 2002-09-30
Date of filing

Stockholm, 2003-10-02

För Patent- och registreringsverket
For the Patent- and Registration Office

Sonia André
Sonia André

Avgift
Fee

PRIORITY DOCUMENT
SUBMITTED OR TRANSMITTED IN
COMPLIANCE WITH
RULE 17.1(a) OR (b)

BEST AVAILABLE COPY

A method for calibration of milk meters in a milking system

Technical field

The present invention relates to method for calibration of milk meters in a milking system, preferably an automatic milking system, as defined by the preamble of claim 1.

Background to the invention

In an automatic milking system, several milk meters are normally used to measure the amount of milk produced by the milking animals in a herd. Each milking animal may be milked using one or more of these milk meters depending on the milking occasion. The milk meters used are calibrated on a routine basis to ensure that each of them measures the correct amount. This routine will entail unnecessary calibration of some milk meters and at the same time there is a risk that other milk meters have been measuring an incorrect amount of milk during a period of time.

An obvious solution to reduce the number of incorrectly measuring milk meters is to decrease the time between routine calibrations of all milk meters. Another solution could be to regularly check and verify the function of each milk meter, to determine if a milk meter is in need of a calibration, but this will decrease the through put in the automatic milking system.

In an article with the title "A method for continuous automatic monitoring of accuracy of milk recording equipment", by G. Wendl, X Zenger and H. Auernhammer, published in EAAP Publication No 65, 1992, pages 338 to 345, a method for identifying a malfunctioning or deviating milk meter is disclosed. The method only describes how to identify a malfunctioning milk meter by using previously recorded actual

milk yields and comparing them with calculated expected milk yields. The method may also be adapted to automatic milking systems if the time lapsed since the last milking is entered into the calculation of expected yield.

5 When a malfunctioning milk meter has been identified, a manual re-calibration of the malfunctioning milk meter is performed. The described method is limited in use since it assumes that the systematic error in measurement does not worsen at the same time on all milk meters, that an error in measurement
10 will drift in one direction (directed error), and that the other milking equipment has no defects.

Summary of the invention

The object of the invention is to provide a method for automatically recalibrating at least one milk meter in a
15 milking system.

This object is achieved by a method as defined in the characterising portion of claim 1.

An advantage with the present invention is that a verification of a properly functioning milking system is performed
20 automatically on a regular basis.

Another advantage is that it is possible to detect and correct a systematic error in measurement that does worsen at the same time on all milk meters.

Still another advantage is that a manual calibration of a milk meter, which takes time and decreases the through-put in the
25 milking system, is not necessary. The calibration is instead performed by adding a correction function to the output of the milk meter, which is in need of calibration, and is done fast and does not affect the through-put of the milking system.

Brief description of the drawings

The invention will now be described in connection with the appended drawings, in which:

5 Fig. 1 shows a first embodiment of a milking system where the invention may be implemented.

Fig. 2 shows a second embodiment of a milking system where the invention may be implemented.

Fig. 3 shows a third embodiment of a milking system where the invention may be implemented.

10 Fig. 4 shows a fourth embodiment of a milking system where the invention may be implemented.

Fig. 5 shows a flow chart for measuring and storing milking performance values.

15 Fig. 6 shows a graph illustrating the method of calculating an expected performance value.

Fig. 7 shows an example of a lactation curve for a milking animal.

Fig. 8 shows a flow chart for calibration of a milk meter according to the invention.

20 **Detailed description of preferred embodiments**

Figure 1 shows a first embodiment of a milking system comprising two milking stations 10a and 10b. Each milking station is placed within some type of milking parlour and comprises four teat cups 11, which are attached to the milking
25 animal during milking operations, and a collector 12, such as a claw. The milk from all teat cups passes the collector 12 and is transported via line 13 to a milk meter 14a and 14b,

respectively. Several milk meters may be used for measuring the milking performance in each milking station, e.g. a milk meter for each teat, but in this embodiment only one milk meter is used for each milking station 10a, 10b.

5 The milk meters 14a and 14b are separately and independently connected to a control unit 15 via a communication line 16. Each milk meter measures a value that corresponds to the milking performance of the milking animal in question, e.g. milk flow over time, the total weight or volume of the milk.
10 The value corresponding to the milking performance of the animal is registered in the control unit 15, preferably in a memory or a database 17. The measured values are used in the method according to the invention.

Furthermore, the control unit 15 comprises means to calculate
15 an expected milking performance value. The expected performance value is used to determine if a milk meter is in need of a calibration, as described below. A display 18 is also connected to the control unit 15.

When the milk has passed each milk meter 14a, 14b the milk is
20 transported to a common receiver 19.

Figure 2 shows a second embodiment of a milking system comprising only one milking station 20, preferably placed in an automatic milking system using a robot. The milking station 20 comprises four teat cups 11, which are attached to the
25 milking animal during milking operations. The teat cups are attached to a respective milk meter 21a, 21b, 21c and 21d, commonly denoted 21.

The milk meters are separately connected to a control unit 15 via a communication line 16. The milk meters 21 measures the
30 milking performance of the respective teat of the milking

animal. The measuring of the milking performance is performed in a manner previously described in connection with figure 1. The measured values are stored in a memory or a database 17 within the control unit 15 and are used in the method according to the invention.

Also in this embodiment the control unit 15 comprises means to calculate an expected milking performance value. The expected performance value is used to determine if a milk meter is in need of a calibration, as described below. A display 18 is also connected to the control unit 15.

Figure 3 shows a third embodiment of the present invention comprising one milking station 30 having four teat cups 11, which are attached to the milking animal during milking operations. The teat cups are attached to a common milk meter 31.

The milk meter 31 is connected to a control unit 15 via a communication line 16. The milk meter 31 measures the milking performance of all teats of the milking animal, in a manner previously described in connection with figure 1. The measured value is stored in a memory or a database 17 within the control unit 15 and is used in the method according to the invention.

Also in this embodiment the control unit 15 comprises means to calculate an expected milking performance value. The expected performance value is used to determine if a milk meter is in need of a calibration, as described below. A display 18 is also connected to the control unit 15.

When the milk has passed the milk meter 31 the milk is transported to a common receiver 19, which may have a sensor (not shown), such as a float sensor, pressure sensors or a

weight sensor, that measures the amount of milk in the receiver. The sensor, if present, is also connected to the control unit 15 via a communication line 35.

When a milk truck 32 arrives to a milking system 36, as indicated by the dashed line, to transport the milk in the receiver 19 to a dairy plant, the tank of the truck 32 is connected to the receiver 19 via a milk meter 33. The milk meter 33 is carried by the milk truck 32 and attached to the inlet of the tank. The purpose of the milk meter 33 is to measure the amount of milk collected from the milk system 36, i.e. the amount of milk in the receiver 19. This milk meter is normally calibrated often, and should therefore show an accurate value. The measured amount of the milk meter 33 may be fed back to the control unit 15 via communication line 34, but it is also possible to manually feed this information into the control unit 15.

Figure 4 shows a fourth embodiment of the present invention comprising two milking stations 10a and 10b. Each milking station is placed in some type of milking parlour and each milking station comprises four teat cups 11, which are attached to the milking animal during milking operations. The teat cups of each milking station are connected to a first milk meter 41a and 41b. The milk from each first milk meter is thereafter transported to an intermediate milk meter 42a and 42b respectively, via a collector 12, which preferably contains the whole volume of the milk received from the udder. The milk meters 41a, 41b, 42a and 42b are provided with means to measure a value corresponding to the milk performance and the first milk meters preferably measures the milk flow and the intermediate milk meters preferably measures the weight of the milk collected from the milking animal. The first milk meters 41a, 41b are separately and independently connected to

a control unit 15 via a communication line 43 and the intermediate milk meters 42a, 42b are separately connected to the control unit 15 via a communication line 44. Values from all milk meters corresponding to the milking performance of the animal in question are registered in the control unit 15, preferably in a memory or a database 17. The measured values are used in the method according to the invention.

The control unit 15 comprises means to calculate an expected milking performance value. The expected performance value is used to determine if a milk meter is in need of a calibration, as described below. A display 18 is also connected to the control unit 15.

When the milk has been collected in the intermediate milk meter 42a, 42b, and the amount of milk has been measured, the milk is transported to a common receiver 19, which in this embodiment has a sensor (not shown) that measures the total amount of milk from all present milking stations 10a, 10b. The sensor is also connected to the control unit 15 via a communication line 35.

When a milk truck 32 arrives at the milking system 40, indicated by the dashed line, to transport the milk in the receiver 19 to a dairy plant, the tank of the truck 32 is connected to the receiver 19 via a milk meter 33. The milk meter 33 is carried by the milk truck 32 and attached to the inlet of the tank. The purpose of the milk meter 33 is to measure the amount of milk collected from the milk system 40, i.e. the amount of milk in the receiver 19. This milk meter is normally calibrated often, and should therefore show an accurate value. The measured amount of the milk meter 33 may be fed back to the control unit 15 via communication line 34,

but it is also possible to manually feed this information into the control unit 15.

The milk meters in the above described types of milking systems 36 and 40 may be monitored using the method according to the invention, which will be described in more detail below.

It is essential that the system comprises means to calculate an expected milking performance value at a given time for each animal in the system according to figure 1, 3 and 4, and for each teat in the system according to figure 2, if the system should be able to monitor and individually recalibrate a milk meter that has an error in measurement. The expected performance value may be calculated in a number of ways, one of which is disclosed in the article previously mentioned in the background to the invention written by G. Wendl, X Zenger and H. Auernhammer.

Figure 5 shows a flow chart describing the method for measuring a milking performance and collecting the information in a memory/database. The flow starts, step 50, and the method determines if a new animal is present to be milked, step 51. If no new animal is present the flow is fed back to point 52. If a new animal is present the flow continues to step 53, where the identity of the animal is read, e.g. by means of a transponder, tags or similar means.

When the identity is determined the teat cups are attached to the teats, step 54, and the milking operation, step 55, commences. The milking performance is measured for each milk meter present in the milking system, step 56. A milk meter may be measuring a parameter value that corresponds to the amount of milk from a part of the udder, or the total amount of milk from the whole udder, depending on the type of automatic

milking system, see figures 1 to 4. The values are stored in a memory or database, step 57, together with information regarding the milk meter used, the point of time and the identity of the animal. This information is needed to determine if a milk meter having an error in measurement.

The last step of the milking procedure is when the milk from all milk meters is collected in the common receiver, step 58, and the flow is thereafter fed back to point 52. The amount of milk collected in the receiver may also be measured and stored in the control unit 15, if a means to measure the amount of milk in the receiver is present.

The calculation of the expected performance value may, as mentioned before, be done in several ways and include different components.

The first component that needs to be taken into account is at least one previously measured and stored milking performance value for the same animal as the calculation is made. A good approximation of an expected performance value is to take the previously stored milking performance value and use it as the expected performance value for next milking occasion, since the change in performance value between milking occasions normally is only minor provided the time between the milking occasions is approximately the same. However this simple approach has the drawback that an incorrect expected performance value may be used if the previous measured performance value was measured by a milk meter being in need of a calibration.

A better way of acquiring a reasonable good expected performance value is to use several previously recorded milking performance values to calculate a mean value over a

selected time period, provided the time between the milking occasions is approximately the same.

The time between milking occasions in a voluntary milking system is as a rule not the same. This is one of the advantages with that type of system, since different animals have different needs when to be milked. Some animals prefer to be milked rather often compared to others. The calculation of the first component as described above is thus not applicable. A different model is required. Figure 6 shows a graph where several previous measured milking performance values are used to create an expected milking performance curve. This curve is created for a selected animal from which the milking performance value for next milking occasion may be determined. This is done by arranging, preferably in a best fit manor, a straight line 61 through origin of coordinates and using the previously measured values 62. The expected performance value 63 is thereafter determined at the time t_1 , which in this example is approximately 16 litres due to the slope of the line 61. It is also possible to express the line 61 as an equation and thereafter calculate the expected performance value there from

If many previously measured milking performance values are used to calculate the expected milking performance value, the influence of any incorrectly measured values will be reduced. Any previously measured milking performance value that deviate too much from the corresponding expected performance value should be eliminated when calculating coming expected performance values, as described below.

A second component that may be taken into account when calculating the expected milking performance value is the shape of the lactation curve of each animal, which means that

the expected value will depend on where on the lactation curve the milking animal is. An example of a lactation curve 70 is shown in figure 7. As can be seen the amount of milk produced by a milking animal varies over time. The lactation curve could therefore be used to further improve the expected performance value.

A third component for calculating the expected performance value is to monitor the nutrition balance, e.g. water/feed intake of each milking animal, since this also will have impact on the amount of milk that could be produced.

A fourth component for calculating the expected performance value is to compensate for the lactation cycle of each milking animal, since this milking animal will produce a different amount of milk depending on which lactation curve the milking animal presently is in.

A fifth component for calculating the expected performance value is to compensate if an animal is sick. The ability to produce milk may be greatly reduced during sickness.

An improved way to determine if a milk meter needs to be calibrated may be performed by using the proposed method in the article mentioned in the background to the invention. The discrepancy between actual and expected milk yield is calculated from:

$$d_{ikl} = m_{ikl} - M_{ikl}$$

where

d_{ikl} equals deviation of expected milk yield from actual milk yield of cow k on day i and meter l

m_{ikl} equals recorded actual milk yield of cow k on day i and meter l

M_{ik} equals expected milk yield of cow k on day i

The reliability of the monitoring method depends on the calculation of a realistic expected value. The expected yield and its standard deviation is calculated from

$$5 \quad M_{ik} = \frac{m_{i-7;k} + m_{i-6;k} + \dots + m_{i-1;k}}{u_{ik}}, \text{ and}$$

$$SM_{ik} = \sqrt{\frac{\sum (m_{i-x;k} - M_{ik})^2}{u_{ik}}},$$

where

$m_{i-x;k}$ equals recorded actual milk yield of cow k on day $i-x$

10 SM_{ik} equals standard deviation of expected milk yield of cow k on day i

u_{ik} equals number of available amounts of milk from cow k during the previous 7 days

15 The expected yield and its standard deviation is calculated across the previous 7 days in this example. To minimize the influence of any deviating milk meter, only amounts of milk that have been recorded on at least 3 different milk meters are used to determine if a specific milk meter has to be calibrated.

20 Extreme values have to be identified and eliminated to calculate the expected value. These extreme values may depend on the cow health, amount of nutrient received by the cow, environmental issues (e.g. introduction of a new member in the herd, etc.). The reason for the extreme values is not essential, but they must be eliminated to calculate a realistic expected value. Some criteria are presented in the article, such as:

25

- only milk yield from 30th to the 300th days in lactation are used.
- an expected value is valid only if the coefficient of variation ($SM_{ik} \cdot 100 / M_{ik}$) is below 20%.
- 5 - if the standard deviation of the available amounts of milk is more than 1.0, only the amounts in the range $M_{ik} \pm 2 \cdot SM_{ik}$ (i.e. 95.45% of normal distribution) are used to calculate a new expected value.
- an expected yield is calculated only if at least 4 milk
- 10 yield records are available across the previous 7 days, fulfilling the above mentioned conditions.
- a deviation is only calculated if the actual milk yield is in the range $M_{ik} \pm 2 \cdot SM_{ik}$.

15 The calculation of average deviation for each milk meter and its standard deviation is calculated from:

$$D_{ii} = \frac{d_{i-30;k,j} + d_{i-29;k,j} + \dots + d_{i-1;k,j}}{x_{ii}}, \text{ and}$$

$$SD_{ii} = \sqrt{\frac{\sum (d_{iu} - D_{ii})^2}{x_{ii} - 1}},$$

where

D_{ii} equals running average of deviations of meter i at time i

20 SD_{ii} equals standard deviation of deviations of meter i at time i

x_{ii} equals number of available deviations of all cows during the previous 30 days (interval 1-30 to $i-1$) on meter i

25 Additionally, it is assumed that the calculated deviations have a normal distribution. Therefore the hypothesis $H_0 (D_{ii}=0)$ can be tested against hypothesis $H_1 (D_{ii} \neq 0)$. If the hypothesis H_0

is rejected over a period of seven running days, a milk meter error is signalled.

When a milk meter has been determined to be in need of calibration, the system may either alert the farmer by sending a message to the display 18 or the system may automatically correct the malfunctioning milk meter by adding a correction function to the faulty, or deviating, milk meter. This is performed by the control unit 15.

To be able to correctly perform an automatic calibration, the system needs to have, in addition to the deviation values for each milk meter, access to a reference value which is used to control the calibration process.

Figure 8 shows a flow chart describing the calibration process, when a milk meter has been found to deviate, as described above.

The flow starts at step 80 and the process awaits a decision to proceed with the calibration of a deviating milk meter in step 81. The flow is fed back in a loop to point 82 until a decision is made to proceed with calibration of one or several milk meters. The process then proceeds to step 83, where a reference value RV, which reflects the amount of milk received from a number of milking animals during a selected period in a reference unit, is determined. The following examples will exemplify how a reference value is determined.

The process thereafter proceeds to step 84, where the measured performance values PV_{meas} are retrieved for each milk meter that by itself contribute to the amount of milk received by the reference unit. Each milk meter is directly or indirectly connected to the reference unit. In step 85, the sum of the retrieved measured performance values is compared with the

reference value and if a specific milk meter has been found to be in need of calibration, that specific milk meter is adjusted so that the reference value is equal to the sum of the measured performance values. On the other hand if no milk meter has been found to be in need of calibration, but the reference value still differs from the sum of the retrieved measured performance values, then all milk meters may be adjusted so that the reference value is equal to the sum of the measured performance values, provided the reference value is considered to be an accurate value. If the reference value cannot be considered to be an accurate value the milk meters are not adjusted.

On the other hand if the reference value for instance has been determined by a newly calibrated milk meter (e.g. on a milk lorry) or the receiver 19 has several independent sensors that together are used to calculate the reference value, all milk meters may be adjusted if the reference value and the sum of the retrieved measured milking performance values differs more than the systems error margin. Also historic data from the milk meters may be used to determine if all milk meters should be adjusted.

The flow is fed back to point 82, awaiting a new decision to proceed with another calibration procedure.

The method described in the article mentioned in background to the invention, assumes that not all milk meters are faulty at the same time, but the method according to the invention actually takes care of that by using an internal reference value (e.g. obtained from the sensor in the receiver 19) or an external reference value, e.g. obtained from a milk meter 33 arranged on a milk truck 32 that regularly transfer the milk in the common receiver 19 to the truck 32. This milk meter is

normally calibrated at regular intervals and thus produces a very reliable reference value when the common receiver 19 is emptied and transferred to the truck 32.

5 During milking, the system may detect that some milk is "not consumption milk" e.g. contain bacteria etc., which means that the milk is discarded and thus not collected in the common receiver. When retrieving the measured performance values that are directly or indirectly connected to the common receiver 19, the performance value that corresponds to the amount of
10 the not consumption milk has to be omitted. If not, the comparison between the reference value and sum of the measured performance values is misleading. The measuring of the not consumption milk may still be used to control the milk meters using the method according to the article.

15 As mentioned above, the reference value does not have to be an external value, but may advantageous be an internally generated value from a device, such as a sensor or milk meter, having at least one milk meter connected to it.

20 The method according to the invention will be described in the following by a number of examples.

Example 1

25 This example will be exemplified using the milking system in figure 1. Each milk meter 14a, 14b measures the milking performance of one animal at the time. A corresponding expected performance value is calculated using the proposed method from the article described above. The measured performance values are presented for both milk meters 14a, 14b in table 1.

30 The common receiver 19 in figure 1 is provided with means (not shown) to measure the amount of milk present in the receiver.

This means is normally a sensor attached to the receiver, which typically measures the weight or volume of the milk,

The means to measure the amount of milk in the receiver is connected to the control unit 15, and the signal from it is used as a reference value when performing the calibration procedure.

Milking occasion	Milk meter 14a		Milk meter 14b	
	Milking animal	PV _{meas}	Milking animal	PV _{meas}
1	1	4.3	2	4.4
2	6	4.7	7	5.3
3	4	4.8	5	3.9
4	7	3.7	8	6.5
5	8	4.6	9	3.5
6	10	5.0	1	6.4
7	2	4.5	3	5.6
8	5	3.8	6	5.2
9	3	4.6	4	4.7
10	9	5.0	10	6.2
	Σ PV _{meas,1}	45.0	Σ PV _{meas,2}	51.7

Table 1

In this example the common receiver 19 did not contain any milk at the time for milking occasion #1, and the reference value (RV) after milking occasion 10 corresponded to 92.3 litres of milk.

If a milk meter is found to be in need of calibration, e.g. milk meter 14b has been found to deviate, the calibration

process is initiated by proceeding to step 83 in figure 8. The RV is established to be 92.3 litres and milk meter 14a and 14b are both directly connected to the common receiver 19.

5 Therefore the sum of the measured performance values for milk meter 14a and 14b is compared with the RV and the faulty milk meter is adjusted with a correction function C, e.g. a constant, an equation, etc. C is, in this example, calculated using the following relationship:

$$RV = PV_{\text{meas},1} + C * PV_{\text{meas},2}$$

10
$$C = \frac{RV - PV_{\text{meas},1}}{PV_{\text{meas},2}} = \frac{92.3 - 45}{51.7} = 0.915$$

The sensor in the common receiver 19 may also in turn be calibrated when the receiver is emptied. The milk truck (not shown) that collects the milk from the milking system is provided with a milk meter attached at the inlet of the tank, 15 which measures the flow of the milk when the receiver is emptied. The total amount of milk emptied from the receiver 19 should correspond to the amount of milk measured by the sensor prior to the transfer of milk to the milk truck. If they 20 differ, the control unit may calculate a correction function for the sensor and thereby calibrate the means for measuring the amount in the receiver 19 at a regular basis, i.e. every time the receiver 19 is emptied.

25 A similar example could be made for the milking system illustrated in figure 2, with the exception that each milk meter only measures a quarter of the milk provided from the milking animal, since one milk meter is attached to each teat cup. The calibration procedure as described above is the same.

Example 2

This example will illustrate how all milk meters (including sensors in the receiver 19) in a milking system may be calibrated when a milk truck 32 empties the receiver 19.

In this example only one milking station is present, se figure 3, having only one milk meter 31 which communicates with the control unit 15, a receiver 19 provided with a sensor (not shown) which also communicates with the control unit 15. When a milk truck 32 arrives to collect the milk in the receiver 19, a milk meter 33, attached to the inlet of the milk tank on the milk truck, is connected to the control unit 15 so that the system may receive a value corresponding to the amount of milk transported into the milk truck 32.

During a calibration procedure performed within the system, using the measured milk volume in the receiver 19 as the internal reference value for calibrating the milk meter 31, the following correction function was calculated:

$$C = \frac{RV}{PV_{meas}} = \frac{92.3}{98.0} = 0.942$$

This correction function was stored in the memory 17 of the control unit 15. When the milk truck arrives and connects to the milking system, the following values was accessible to the control unit 15.

Milk volume in receiver (measured by the sensor): 183.5 litres

Sum of all actually measured milking performance values of the milk meter 31 since the last time the receiver 19 was emptied: 197.8 litres

The correction function, previously determined using an internal reference value, is stored in the control unit, will correct the sum of all PV_{meas} to be $0.942 \cdot 197.8 = 186.3$, which is

close enough to the amount of milk measured by the sensor in the receiver 19.

When the milk in the receiver 19 has been transferred to the milk truck, the control unit receives the actual milk volume from the milk meter 33, which in this example is 201.3 litres.

The control unit selects the measured milk volume from milk meter 33 as an external reference value and uses this information to recalibrate the sensor in the receiver by adding a receiver correction function, which in this example is $201.3/183.5=1.097$. The correction function for the milk meter 31 is also corrected by multiplying the previous correction constant with the receiver constant, e.g. $0.942*1.097=1.033$.

The control unit in the milking system will now use the correction functions when receiving measurement values from the milk meter 31 and the sensor to calculate a calibrated value for them. In this way there is no need to physically calibrate the milk meter or sensor, since an automatic adjustment, implemented as a software related calibration, is made in the control unit of the milking system.

Example 3

This last example is illustrated in connection with figure 4, which in its basic components is similar to the milking system in figure 1, with the exception that each teat cup 11 is connected to the collector 12 via a first milk meter 41a, 41b. The first milk meter 41a, 41b measures preferably the milk flow of each teat and the second milk meter 42a, 42b measures the weight or volume of the total amount of milk.

In this system calibration checks may be performed in a number of different ways, using the measured milking performance values of a milk meter to calibrate other milk meters attached

to the milk meter that is used to establish the reference value. As an example the intermediate milk meter 42a may be used to determine if one of the first milk meters 41a needs to be calibrated, and the intermediate milk meter 42b may be used to calibrate any of the first milk meter 41b. The same may be applied for receiver 19 and intermediate milk meters 42a and 42b, as described in connection with example 3.

The examples that have been used to illustrate the method according to the invention have been simplified to clearly point out certain features.

PROJ. 00-30

Claims

1. A method for calibrating at least one milk meter in a milking system (36;40) comprising at least one milking station (10a, 10b; 20; 30) having at least one milk meter (14a,14b; 21a,21b,21c,21d; 31;41a,41b,42a,42b) that measures at least one value of a parameter that corresponds to the milking performance of a milking animal, said milking station is accessible to a herd of milking animals, characterised in that said method comprises the steps of:
- 10 - determining an internal or external reference value (RV) which reflects the amount of milk received from a number of milking animals during a selected time period in a reference unit (19;32;42a,42b),
 - retrieving all measured values during the selected time period for each milk meter (14a,14b;21a,21b,21c,21d; 15 31;41a,41b,42a,42b) that by itself contribute to the amount of milk received by said reference unit (19;32;42a,42b),
 - comparing said reference value (RV) with the sum of all 20 retrieved measured values and calculating a correction function ($C;C_{com}$) for at least one of said milk meters, and
 - using said calculated correction function to adjust the measured value from said at least one milk meter.
- 25 2. The method according to claim 1, wherein said method is used to calibrate one or more milk meters, which has been determined to be in need of a calibration by comparing an expected value of the milking performance with the measured value.
- 30 3. The method according to claim 1 or 2, wherein said reference unit is selected to be a receiver (19) that collects

the milk in the system after milking of each milking animal, and said step of determining the reference value is performed by measuring the amount of the milk in the receiver (19), thus said reference value is an internal reference value.

5 4. The method according to claim 1 or 2, wherein said reference unit is selected to be an intermediate milk meter (42a, 42b) which is directly connected to at least one milk meter (41a, 41b), and said step of determining the reference value is performed by measuring a value of a milking performance parameter of said intermediate milk meter (42a, 10 42b), thus said reference value is an internal reference value, which may be compared to the values measured by each milk meter (41a, 41b).

15 5. The method according to any of claims 1-4, wherein said milking system is provided with an external unit (32) being provided with an external milk meter (33) to measure the amount of milk transferred from the milking system to said external unit (32), said step of determining the reference value (RV) is performed by measuring the amount of milk 20 transferred from the receiver (19) to the external unit (32) using said external milk meter (33), thus said reference value is an external reference value.

6. The method according to claim 5, wherein the method further comprises the additional steps of:

- 25 - determining the amount of milk in the receiver (19) prior to transferring the milk to the external unit (32),
- comparing said amount of milk in the receiver with the external reference value, and
- 30 - calculating the correction function which is used when determining the amount of milk in the receiver (19).

7. The method according to claim 5 or 6, wherein said method further comprises the additional steps of re-calibrating the milk meters (14a,14b;21a,21b,21c,21d;31;42a,42b) that by themselves contribute to the amount of milk received by the receiver (19) when the correction function has been calculated which is used when determining the amount of milk in the receiver (19).

8. The method according to any of claims 1-7, wherein the correction function is selected to be equal to 1 unless the reference value (RV) deviate more than a predetermined amount from the sum of all retrieved measured milking performance values.

9. The method according to claim 8, wherein said predetermined amount is selected to be 5%.

10. The method according to any of claims 1-9, wherein the milking system comprises a control device (15) connected to each milk meter, said internal or external reference value being accessible to said control unit (15), and said calculations of correction functions is performed in said control unit (15).

Abstract

The present invention relates to a method for calibrating milk meters in a milking system comprising at least one milking station 10a, 10b; 20 having at least one milk meter 5 14a,14b;21a,21b,21c,21d that measures at least one value of a milking performance of a milking animal. The method comprises the steps of: determining a reference value which reflects the amount of milk received from a number of milking animals during a selected time period in a reference unit 19;32, 10 retrieving all measured values during the selected time period for each milk meter 14a,14b;21a,21b,21c,21d that by itself contribute to the amount of milk received by the reference unit 19;32, comparing the reference value with the sum of all retrieved measured values and calculating a correction 15 function for at least one of the milk meters, and using the calculated correction function to adjust the measured value from the at least one milk meter.

P
1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
19
20
21
22
23
24
25
26
27
28
29
30
31
32
33
34
35
36
37
38
39
40
41
42
43
44
45
46
47
48
49
50
51
52
53
54
55
56
57
58
59
60
61
62
63
64
65
66
67
68
69
70
71
72
73
74
75
76
77
78
79
80
81
82
83
84
85
86
87
88
89
90
91
92
93
94
95
96
97
98
99
100
101
102
103
104
105
106
107
108
109
110
111
112
113
114
115
116
117
118
119
120
121
122
123
124
125
126
127
128
129
130
131
132
133
134
135
136
137
138
139
140
141
142
143
144
145
146
147
148
149
150
151
152
153
154
155
156
157
158
159
160
161
162
163
164
165
166
167
168
169
170
171
172
173
174
175
176
177
178
179
180
181
182
183
184
185
186
187
188
189
190
191
192
193
194
195
196
197
198
199
200
201
202
203
204
205
206
207
208
209
210
211
212
213
214
215
216
217
218
219
220
221
222
223
224
225
226
227
228
229
230
231
232
233
234
235
236
237
238
239
240
241
242
243
244
245
246
247
248
249
250
251
252
253
254
255
256
257
258
259
260
261
262
263
264
265
266
267
268
269
270
271
272
273
274
275
276
277
278
279
280
281
282
283
284
285
286
287
288
289
290
291
292
293
294
295
296
297
298
299
300
301
302
303
304
305
306
307
308
309
310
311
312
313
314
315
316
317
318
319
320
321
322
323
324
325
326
327
328
329
330
331
332
333
334
335
336
337
338
339
340
341
342
343
344
345
346
347
348
349
350
351
352
353
354
355
356
357
358
359
360
361
362
363
364
365
366
367
368
369
370
371
372
373
374
375
376
377
378
379
380
381
382
383
384
385
386
387
388
389
390
391
392
393
394
395
396
397
398
399
400
401
402
403
404
405
406
407
408
409
410
411
412
413
414
415
416
417
418
419
420
421
422
423
424
425
426
427
428
429
430
431
432
433
434
435
436
437
438
439
440
441
442
443
444
445
446
447
448
449
450
451
452
453
454
455
456
457
458
459
460
461
462
463
464
465
466
467
468
469
470
471
472
473
474
475
476
477
478
479
480
481
482
483
484
485
486
487
488
489
490
491
492
493
494
495
496
497
498
499
500
501
502
503
504
505
506
507
508
509
510
511
512
513
514
515
516
517
518
519
520
521
522
523
524
525
526
527
528
529
530
531
532
533
534
535
536
537
538
539
540
541
542
543
544
545
546
547
548
549
550
551
552
553
554
555
556
557
558
559
560
561
562
563
564
565
566
567
568
569
570
571
572
573
574
575
576
577
578
579
580
581
582
583
584
585
586
587
588
589
590
591
592
593
594
595
596
597
598
599
600
601
602
603
604
605
606
607
608
609
610
611
612
613
614
615
616
617
618
619
620
621
622
623
624
625
626
627
628
629
630
631
632
633
634
635
636
637
638
639
640
641
642
643
644
645
646
647
648
649
650
651
652
653
654
655
656
657
658
659
660
661
662
663
664
665
666
667
668
669
670
671
672
673
674
675
676
677
678
679
680
681
682
683
684
685
686
687
688
689
690
691
692
693
694
695
696
697
698
699
700
701
702
703
704
705
706
707
708
709
710
711
712
713
714
715
716
717
718
719
720
721
722
723
724
725
726
727
728
729
730
731
732
733
734
735
736
737
738
739
740
741
742
743
744
745
746
747
748
749
750
751
752
753
754
755
756
757
758
759
760
761
762
763
764
765
766
767
768
769
770
771
772
773
774
775
776
777
778
779
780
781
782
783
784
785
786
787
788
789
790
791
792
793
794
795
796
797
798
799
800
801
802
803
804
805
806
807
808
809
810
811
812
813
814
815
816
817
818
819
820
821
822
823
824
825
826
827
828
829
830
831
832
833
834
835
836
837
838
839
840
841
842
843
844
845
846
847
848
849
850
851
852
853
854
855
856
857
858
859
860
861
862
863
864
865
866
867
868
869
870
871
872
873
874
875
876
877
878
879
880
881
882
883
884
885
886
887
888
889
890
891
892
893
894
895
896
897
898
899
900
901
902
903
904
905
906
907
908
909
910
911
912
913
914
915
916
917
918
919
920
921
922
923
924
925
926
927
928
929
930
931
932
933
934
935
936
937
938
939
940
941
942
943
944
945
946
947
948
949
950
951
952
953
954
955
956
957
958
959
960
961
962
963
964
965
966
967
968
969
970
971
972
973
974
975
976
977
978
979
980
981
982
983
984
985
986
987
988
989
990
991
992
993
994
995
996
997
998
999
1000
1001
1002
1003
1004
1005
1006
1007
1008
1009
1010
1011
1012
1013
1014
1015
1016
1017
1018
1019
1020
1021
1022
1023
1024
1025
1026
1027
1028
1029
1030
1031
1032
1033
1034
1035
1036
1037
1038
1039
1040
1041
1042
1043
1044
1045
1046
1047
1048
1049
1050
1051
1052
1053
1054
1055
1056
1057
1058
1059
1060
1061
1062
1063
1064
1065
1066
1067
1068
1069
1070
1071
1072
1073
1074
1075
1076
1077
1078
1079
1080
1081
1082
1083
1084
1085
1086
1087
1088
1089
1090
1091
1092
1093
1094
1095
1096
1097
1098
1099
1100
1101
1102
1103
1104
1105
1106
1107
1108
1109
1110
1111
1112
1113
1114
1115
1116
1117
1118
1119
1120
1121
1122
1123
1124
1125
1126
1127
1128
1129
1130
1131
1132
1133
1134
1135
1136
1137
1138
1139
1140
1141
1142
1143
1144
1145
1146
1147
1148
1149
1150
1151
1152
1153
1154
1155
1156
1157
1158
1159
1160
1161
1162
1163
1164
1165
1166
1167
1168
1169
1170
1171
1172
1173
1174
1175
1176
1177
1178
1179
1180
1181
1182
1183
1184
1185
1186
1187
1188
1189
1190
1191
1192
1193
1194
1195
1196
1197
1198
1199
1200
1201
1202
1203
1204
1205
1206
1207
1208
1209
1210
1211
1212
1213
1214
1215
1216
1217
1218
1219
1220
1221
1222
1223
1224
1225
1226
1227
1228
1229
1230
1231
1232
1233
1234
1235
1236
1237
1238
1239
1240
1241
1242
1243
1244
1245
1246
1247
1248
1249
1250
1251
1252
1253
1254
1255
1256
1257
1258
1259
1260
1261
1262
1263
1264
1265
1266
1267
1268
1269
1270
1271
1272
1273
1274
1275
1276
1277
1278
1279
1280
1281
1282
1283
1284
1285
1286
1287
1288
1289
1290
1291
1292
1293
1294
1295
1296
1297
1298
1299
1300
1301
1302
1303
1304
1305
1306
1307
1308
1309
1310
1311
1312
1313
1314
1315
1316
1317
1318
1319
1320
1321
1322
1323
1324
1325
1326
1327
1328
1329
1330
1331
1332
1333
1334
1335
1336
1337
1338
1339
1340
1341
1342
1343
1344
1345
1346
1347
1348
1349
1350
1351
1352
1353
1354
1355
1356
1357
1358
1359
1360
1361
1362
1363
1364
1365
1366
1367
1368
1369
1370
1371
1372
1373
1374
1375
1376
1377
1378
1379
1380
1381
1382
1383
1384
1385
1386
1387
1388
1389
1390
1391
1392
1393
1394
1395
1396
1397
1398
1399
1400
1401
1402
1403
1404
1405
1406
1407
1408
1409
1410
1411
1412
1413
1414
1415
1416
1417
1418
1419
1420
1421
1422
1423
1424
1425
1426
1427
1428
1429
1430
1431
1432
1433
1434
1435
1436
1437
1438
1439
1440
1441
1442
1443
1444
1445
1446
1447
1448
1449
1450
1451
1452
1453
1454
1455
1456
1457
1458
1459
1460
1461
1462
1463
1464
1465
1466
1467
1468
1469
1470
1471
1472
1473
1474
1475
1476
1477
1478
1479
1480
1481
1482
1483
1484
1485
1486
1487
1488
1489
1490
1491
1492
1493
1494
1495
1496
1497
1498
1499
1500
1501
1502
1503
1504
1505
1506
1507
1508
1509
1510
1511
1512
1513
1514
1515
1516
1517
1518
1519
1520
1521
1522
1523
1524
1525
1526
1527
1528
1529
1530
1531
1532
1533
1534
1535
1536
1537
1538
1539
1540
1541
1542
1543
1544
1545
1546
1547
1548
1549
1550
1551
1552
1553
1554
1555
1556
1557
1558
1559
1560
1561
1562
1563
1564
1565
1566
1567
1568
1569
1570
1571
1572
1573
1574
1575
1576
1577
1578
1579
1580
1581
1582
1583
1584
1585
1586
1587
1588
1589
1590
1591
1592
1593
1594
1595
1596
1597
1598
1599
1600
1601
1602
1603
1604
1605
1606
1607
1608
1609
1610
1611
1612
1613
1614
1615
1616
1617
1618
1619
1620
1621
1622
1623
1624
1625
1626
1627
1628
1629
1630
1631
1632
1633
1634
1635
1636
1637
1638
1639
1640
1641
1642
1643
1644
1645
1646
1647
1648
1649
1650
1651
1652
1653
1654
1655
1656
1657
1658
1659
1660
1661
1662
1663
1664
1665
1666
1667
1668
1669
1670
1671
1672
1673
1674
1675
1676
1677
1678
1679
1680
1681
1682
1683
1684
1685
1686
1687
1688
1689
1690
1691
1692
1693
1694
1695
1696
1697
1698
1699
1700
1701
1702
1703
1704
1705
1706
1707
1708
1709
1710
1711
1712
1713
1714
1715
1716
1717
1718
1719
1720
1721
1722
1723
1724
1725
1726
1727
1728
1729
1730
1731
1732
1733
1734
1735
1736
1737
1738
1739
1740
1741
1742
1743
1744
1745
1746
1747
1748
1749
1750
1751
1752
1753
1754
1755
1756
1757
1758
1759
1760
1761
1762
1763
1764
1765
1766
1767
1768
1769
1770
1771
1772
1773
1774
1775
1776
1777
1778
1779
1780
1781
1782
1783
1784
1785
1786
1787
1788
1789
1790
1791
1792
1793
1794
1795
1796
1797
1798
1799
1800
1801
1802
1803
1804
1805
1806
1807
1808
1809
1810
1811
1812
1813
1814
1815
1816
1817
1818
1819
1820
1821
1822
1823
1824
1825
1826
1827
1828
1829
1830
1831
1832
1833
1834
1835
1836
1837
1838
1839
1840
1841
1842
1843
1844
1845
1846
1847
1848
1849
1850
1851
1852
1853
1854
1855
1856
1857
1858
1859
1860
1861
1862
1863
1864
1865
1866
1867
1868
1869
1870
1871
1872
1873
1874
1875
1876
1877
1878
1879
1880
1881
1882
1883
1884
1885
1886
1887
1888
1889
1890
1891
1892
1893
1894
1895
1896
1897
1898
1899
1900
1901
1902
1903
1904
1905
1906
1907
1908
1909
1910
1911
1912
1913
1914
1915
1916
1917
1918
1919
1920
1921
1922
1923
1924
1925
1926
1927
1928
1929
1930
1931
1932
1933
1934
1935
1936
1937
1938
1939
1940
1941
1942
1943
1944
1945
1946
1947
1948
1949
1950
1951
1952
1953
1954
1955
1956
1957
1958
1959
1960
1961
1962
1963
1964
1965
1966
1967
1968
1969
1970
1971
1972
1973
1974
1975
1976
1977
1978
1979
1980
1981
1982
1983
1984
1985
1986
1987
1988
1989
1990
1991
1992
1993
1994
1995
1996
1997
1998
1999
2000
2001
2002
2003
2004
2005
2006
2007
2008
2009
2010
2011
2012
2013
2014
2015
2016
2017
2018
2019
2020
2021
2022
2023
2024
2025
2026
2027
2028
2029
2030
2031
2032
2033
2034
2035
2036
2037
2038
2039
2040
2041
2042
2043
2044
2045
2046
2047
2048
2049
2050
2051
2052
2053
2054
2055
2056
2057
2058
2059
2060
2061
2062
2063
2064
2065
2066
2067
2068
2069
2070
2071
2072
2073
2074
2075
2076
2077
2078
2079
2080
2081
2082
2083
2084
2085
2086
2087
2088
2089
2090
2091
2092
2093
2094
2095
2096
2097
2098
2099
2100
2101
2102
2103
2104
2105
2106
2107
2108
2109
2110
2111
2112
2113
2114
2115
2116
2117
2118
2119
2120
2121
2122
2123
2124
2125
2126
2127
2128
2129
2130
2131
2132
2133
2134
2135
2136
2137
2138
2139
2140
2141
2142
2143
2144
2145
2146
2147
2148
2149
2150
2151
2152
2153
2154
2155
2156
2157
2158
2159
2160
2161
2162
2163
2164
2165
2166
2167
2168
2169
2170
2171
2172
2173
2174
2175
2176
2177
2178
2179
2180
2181
2182

1/4

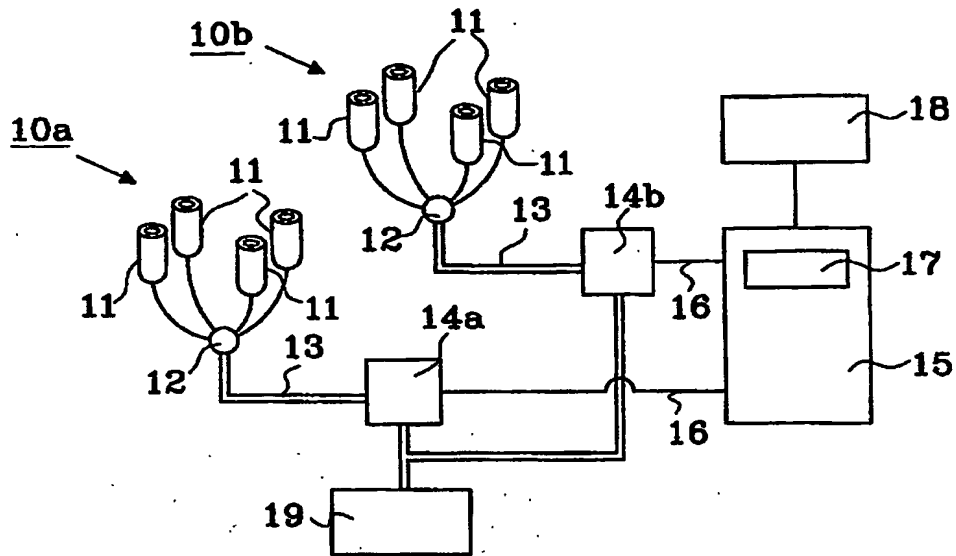


Fig. 1

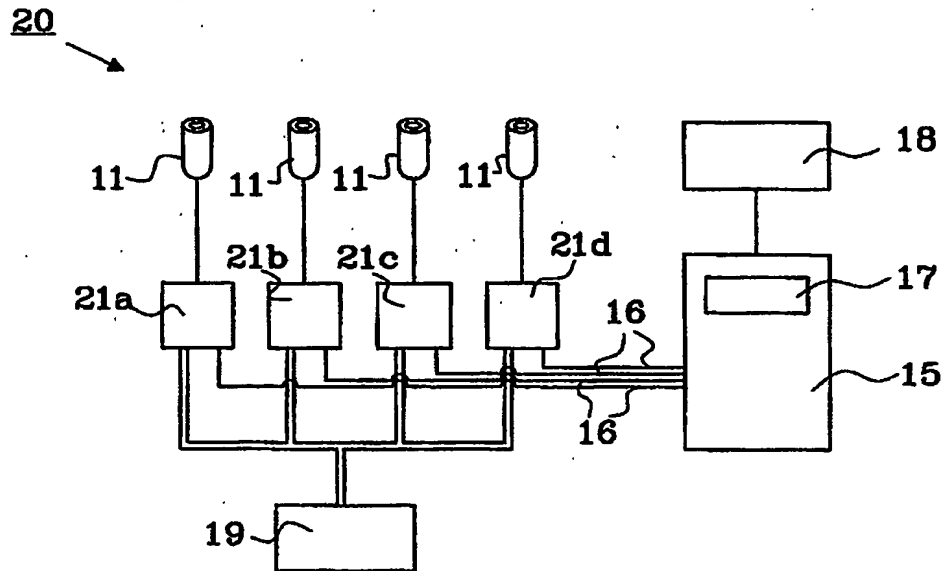


Fig. 2

2/4

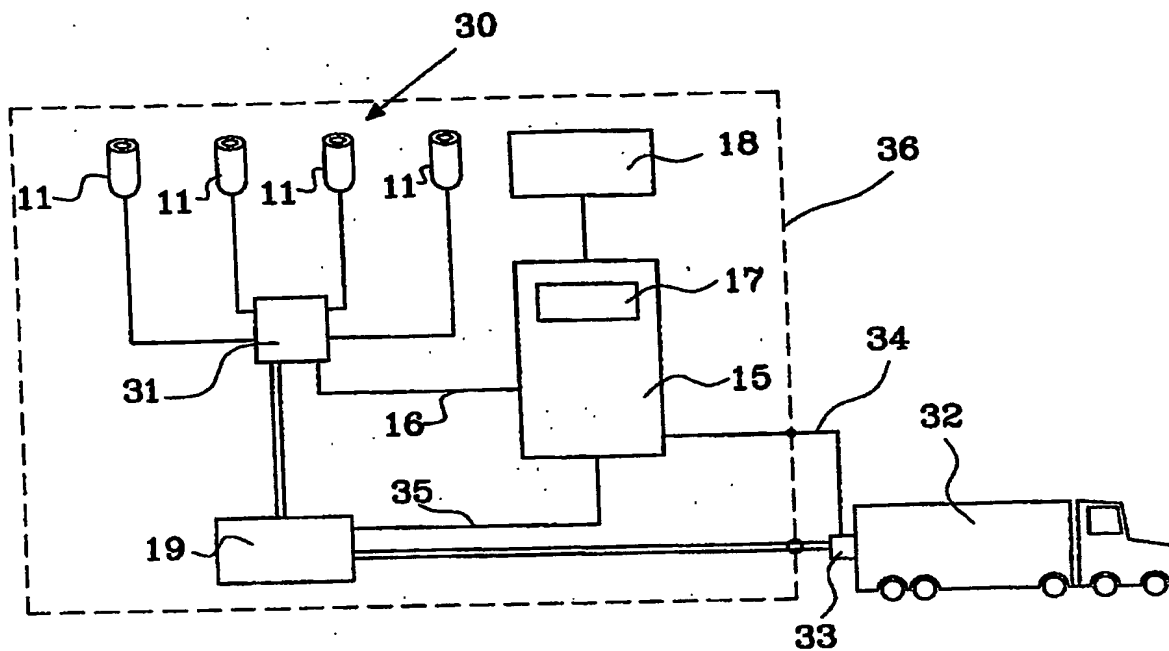


Fig. 3

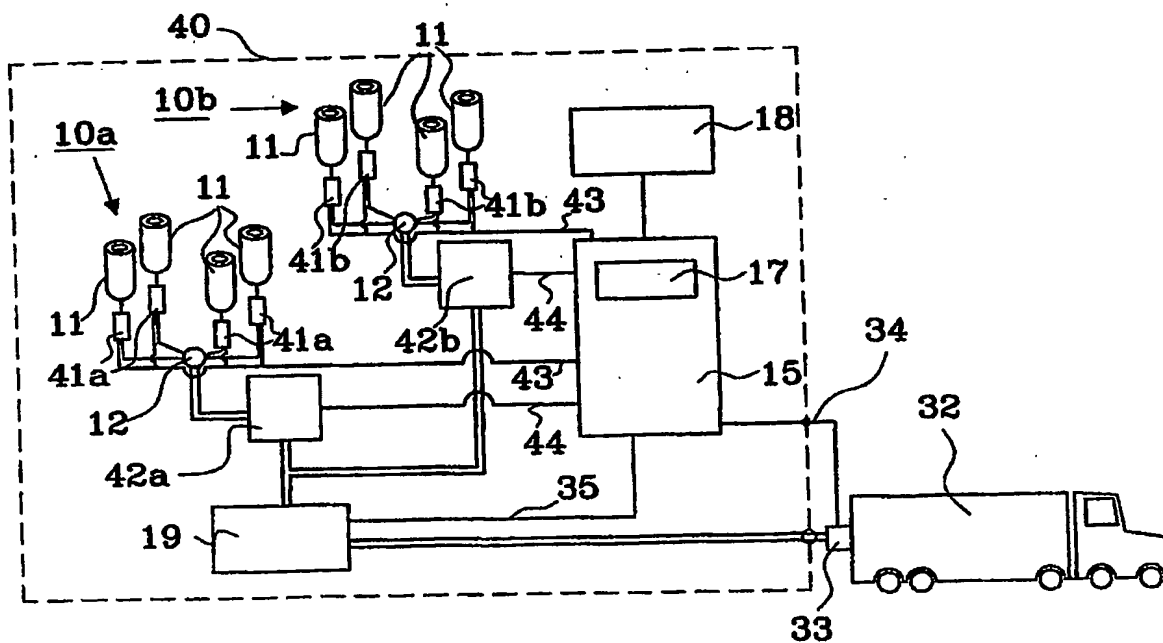


Fig. 4

3/4

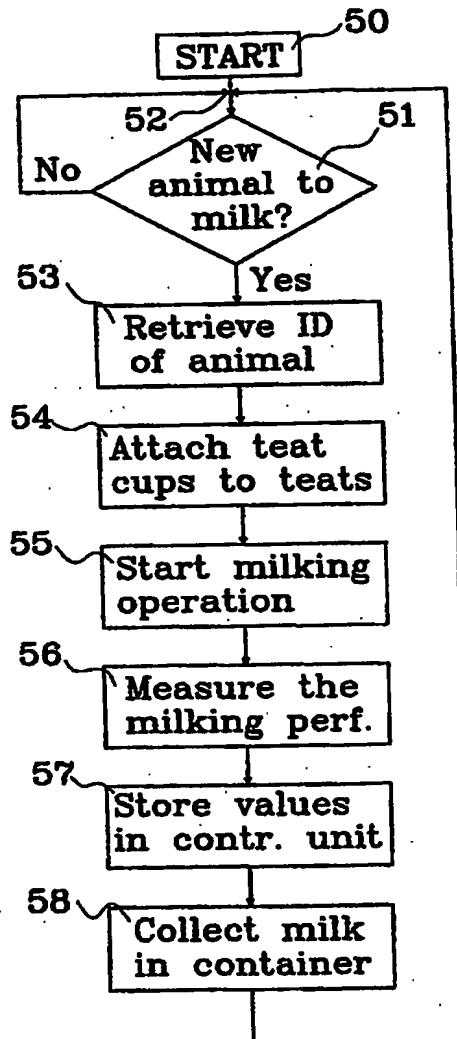


Fig. 5

4/4

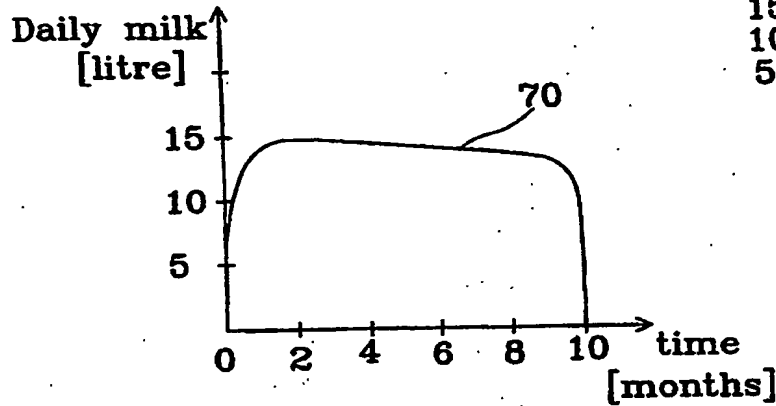


Fig. 7

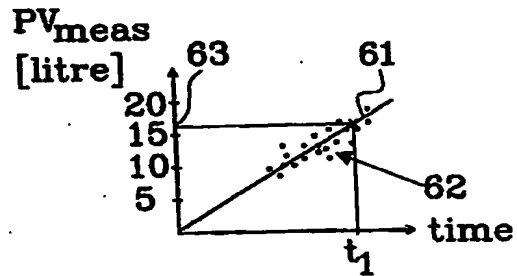


Fig. 6

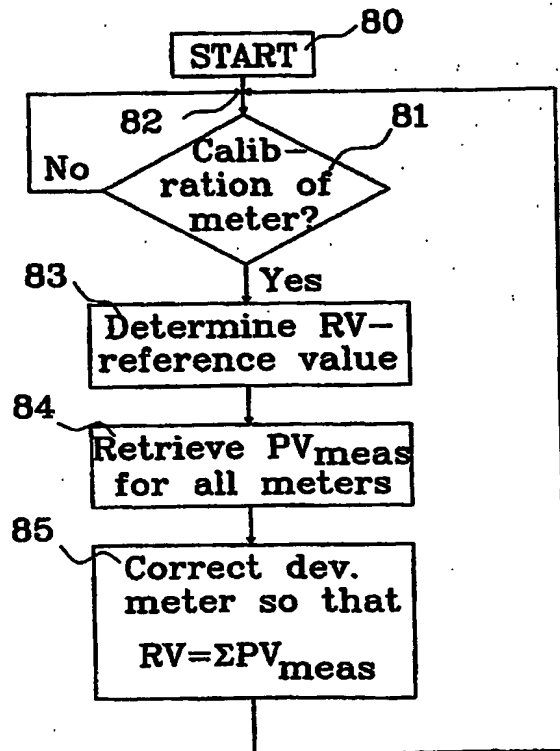


Fig. 8

**This Page is Inserted by IFW Indexing and Scanning
Operations and is not part of the Official Record**

BEST AVAILABLE IMAGES

Defective images within this document are accurate representations of the original documents submitted by the applicant.

Defects in the images include but are not limited to the items checked:

- ☒ **BLACK BORDERS**
- ☐ **IMAGE CUT OFF AT TOP, BOTTOM OR SIDES**
- ☒ **FADED TEXT OR DRAWING**
- ☒ **BLURRED OR ILLEGIBLE TEXT OR DRAWING**
- ☐ **SKEWED/SLANTED IMAGES**
- ☐ **COLOR OR BLACK AND WHITE PHOTOGRAPHS**
- ☐ **GRAY SCALE DOCUMENTS**
- ☐ **LINES OR MARKS ON ORIGINAL DOCUMENT**
- ☐ **REFERENCE(S) OR EXHIBIT(S) SUBMITTED ARE POOR QUALITY**
- ☐ **OTHER:** _____

IMAGES ARE BEST AVAILABLE COPY.

As rescanning these documents will not correct the image problems checked, please do not report these problems to the IFW Image Problem Mailbox.